7.0 Use of oceanographic data in surveys

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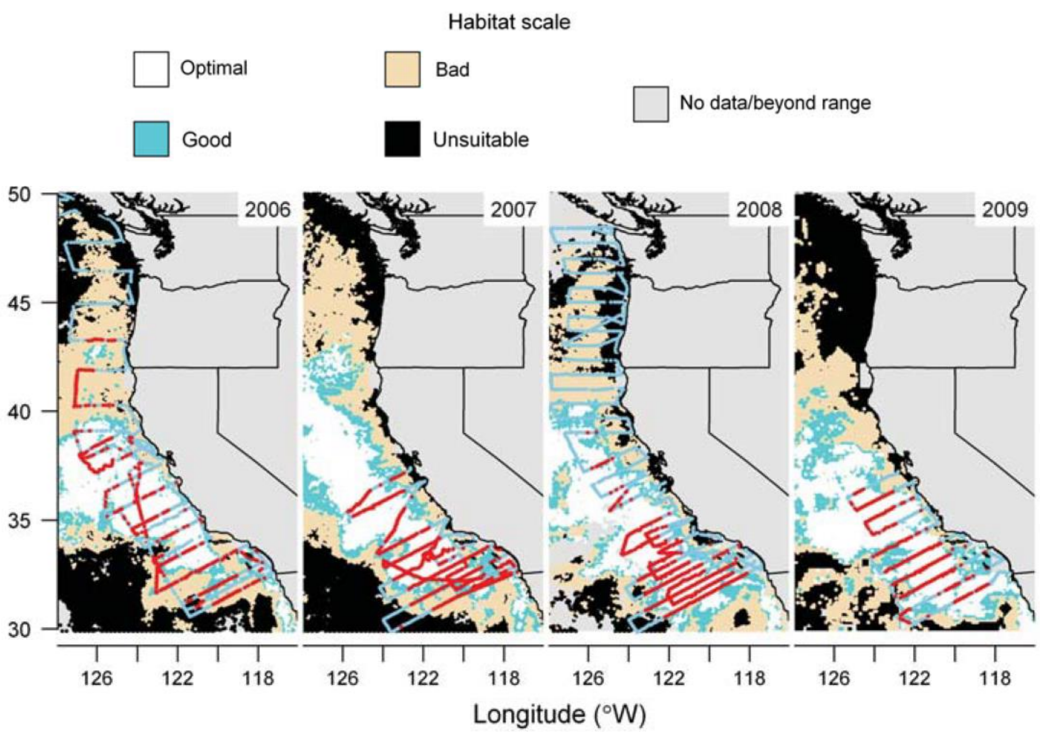
- Oceanography informs assessments by providing ancillary information.
- The relevant contributions of oceanography cover a wide range of topics.

What are these topics where oceanography is relevant to assessments?

- Habitat models of sardine, anchovy, and Pacific mackerel (survey optimization etc.).
- Large scale advection of sardine recruits to Mexico.
- Modeling sardine recruitment (GAMs, GLMs) (temperature control rule).
- Effect of mesoscale variability (the eddy story).
- Explaining how ENSO affects sardine spawning habitat.
- Changes in ichthyoplankton distributions with climate variability.
- Changes in ichthyoplankton assemblages with increasingly acidic waters.
- Linking tracked animals to oceanographic variability (makos and production).
- Albacore fishery in relation to coastal and oceanic frontal variability.

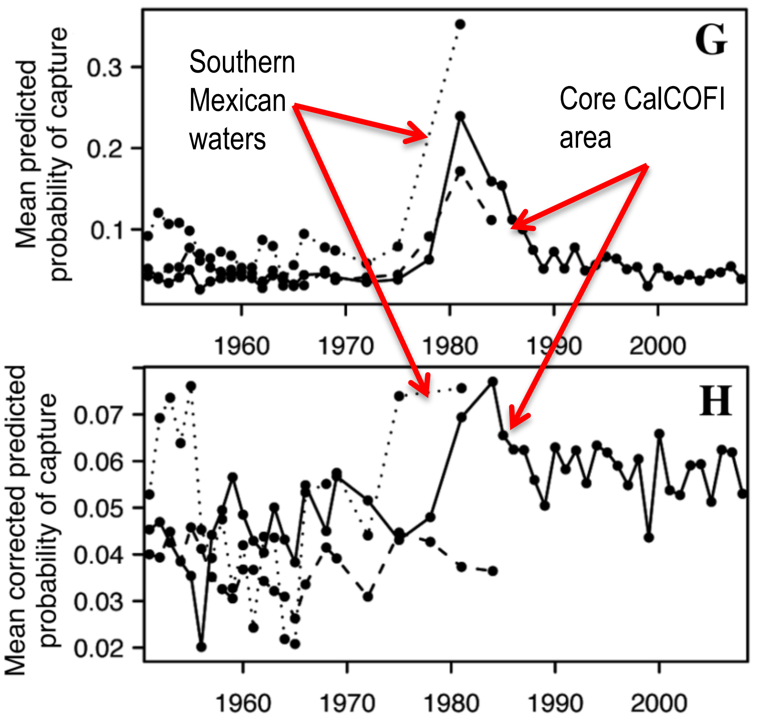
Habitat models of sardine, anchovy, and Pacific mackerel (survey optimization, sampling domain)

Zwolinski et al. 2011, ICES J. Marine Science



- Sardine spawning habitat model provides a very useful guide to predict areas with a high probability of occurrence of sardine eggs during surveys
- Has potential to inform adaptive sampling
- Also predicts seasonal migration of sardine

Weber and McClatchie 2012, Fishery Bull. U.S.



- Pacific mackerel spawning habitat model shows that there is a higher probability of encounter of eggs (and adults) in southern Mexican waters.
- The Mexican domain is poorly sampled by our surveys.

Large scale advection of sardine recruits to Mexico

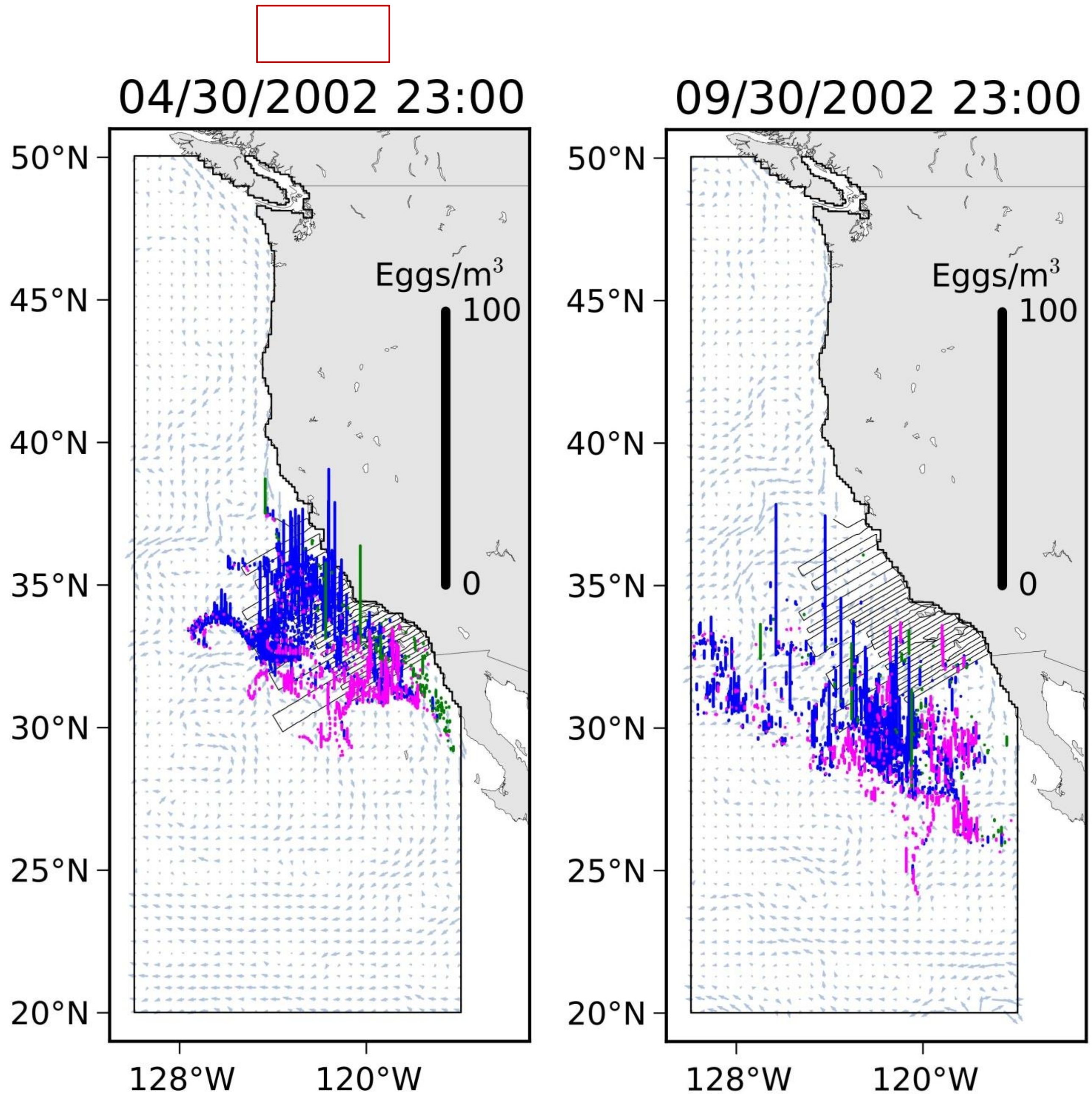
Weber et al. in prep.

Example showing advection of small pelagic fish eggs by a high resolution Regional Ocean Modeling system (ROMS) model of the California Current System. Vertical bars indicate the density of sardine eggs (blue), jack mackerel eggs (pink) and anchovy eggs (green) collected using the CUFES along the cruise track (marked in red) during the spring CalCOFI/ Coastal Pelagic Species cruise of 2002.

Left panel is a snapshot of egg positions during the cruise on April 30, 2002.

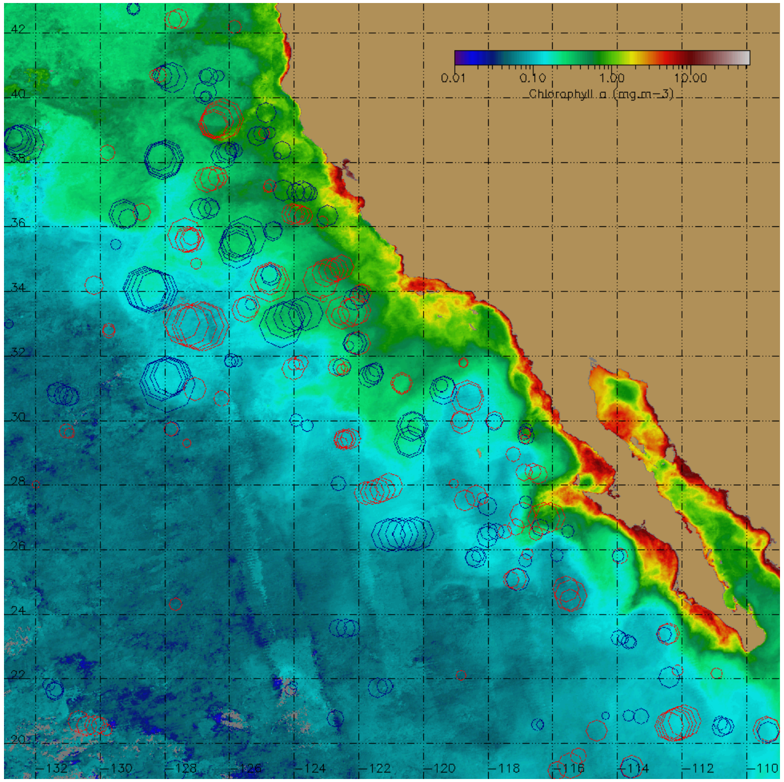
Right panel is a snapshot of the positions of young juvenile fishes 5 months later, assuming development of diel vertical migration but no active horizontal swimming.

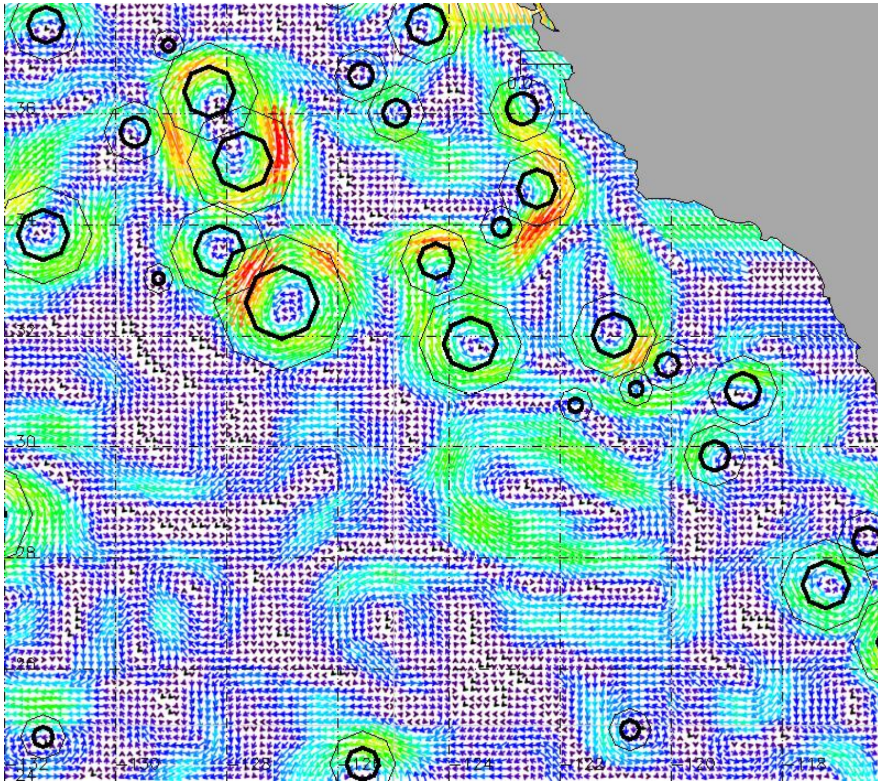
Light blue arrows show mean current vectors in the upper 50 m at this time step



Effect of mesoscale variability (the eddy story)

Nieto, McClatchie, Weber & Lennert, in prep. Journal of Geophysical Research

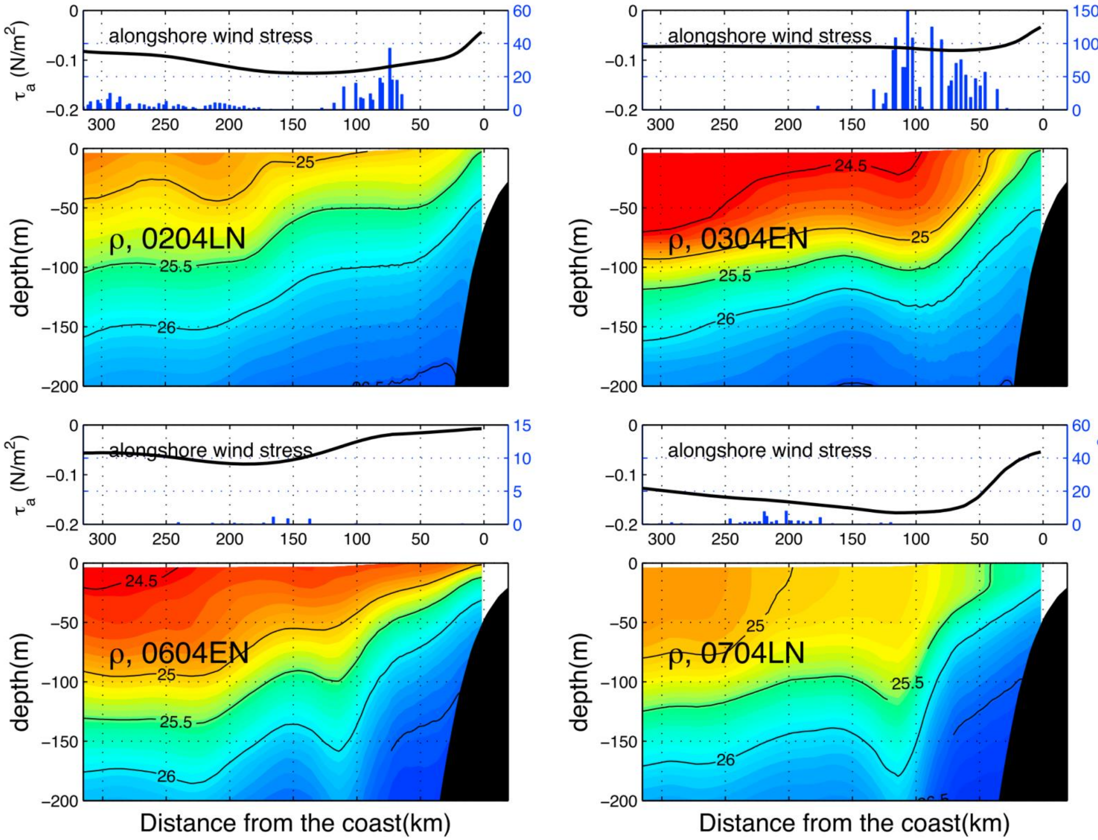




- The effects of eddies on sardine is different from the paradigm that cyclonic eddies provide a stochastic enhancement of production, thereby improving sardine “survivor habitat”.
- Instead, both cyclonic (blue) and anticyclonic (red) eddies entrain mesoscale jets and squirts, and then propagate westward, transporting favorable sardine spawning habitat offshore. Favorable spawning habitat was defined using the habitat model with temperature, salinity and chlorophyll predictors.
- Whether offshore transport is beneficial or unfavorable to sardine recruitment is currently unknown.

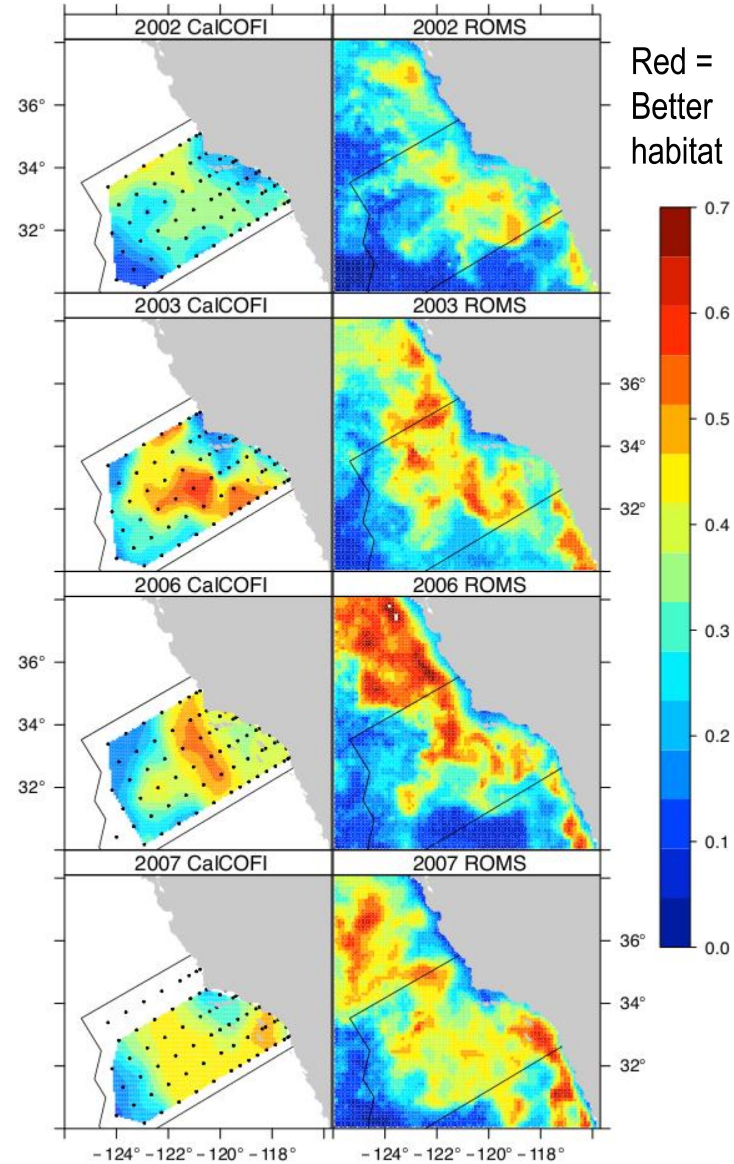
Explaining how ENSO affects sardine spawning habitat

Song et al. 2011, Journal of Geophysical Research



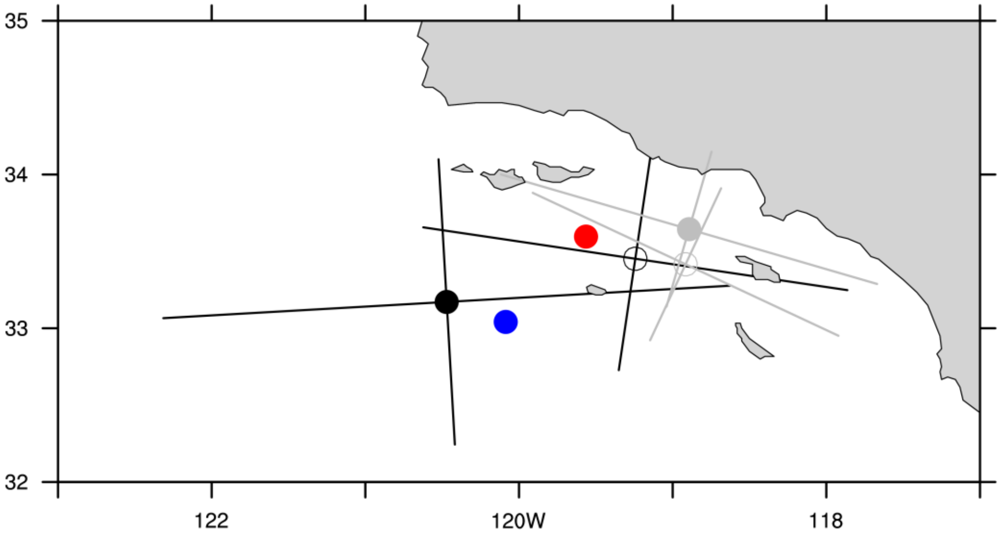
- Stronger equatorward winds drive sardine spawning habitat offshore during La Niña (LN).
- Probability of occurrence of eggs is higher , during El Niño (EN), suggesting better quality spawning habitat.

Spawning habitat model: probability of occurrence of sardine eggs**. Better habitat in 2003 & 2006 El Niños.**



Changes in ichthyoplankton distributions with climate variability

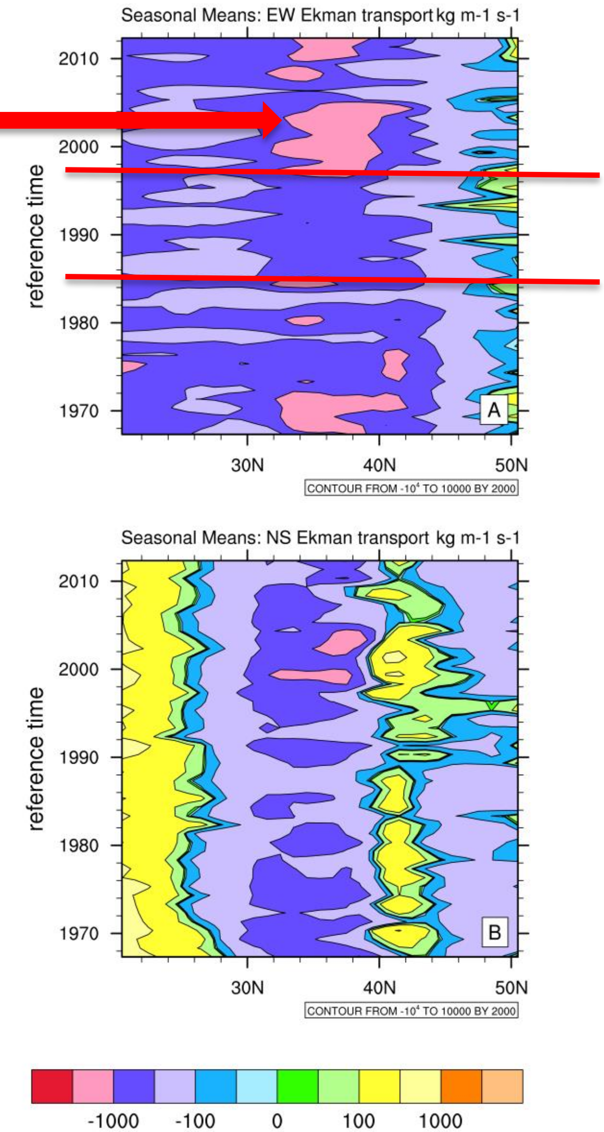
McClatchie and Watson, in prep. Geophysical Research Letters



Centroids of egg distribution by decade, black = sardine, gray = anchovy)
O=**1985-1996**, ●=**1997-2011**, red = EP El Niños, **blue** = EP La Niñas

March-May transport means (FNMOC model)

Stronger westward transport in the years 1997-2011 compared to 1985-1996



Implications of the secular trends :

- Sardine are now spawning in less productive environment off SoCal which may partly explain a shift to spawn off CenCal.
- Sea lions from San Nicolas Is. have to travel further to dine on sardine.
- Secular trends are of the same magnitude as Inter-annual ENSO differences.
- Secular and Inter-annual variability strongly influenced by wind-driven offshore transport.

Changes in ichthyoplankton assemblages with increasing acidic waters

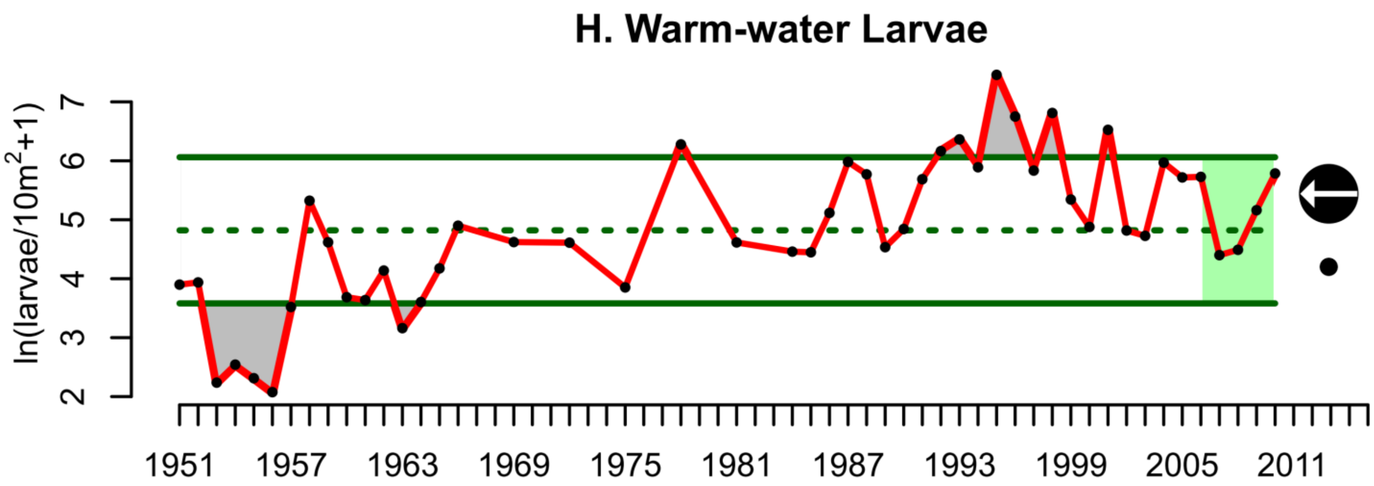
McClatchie, Thompson & Watson, in prep.

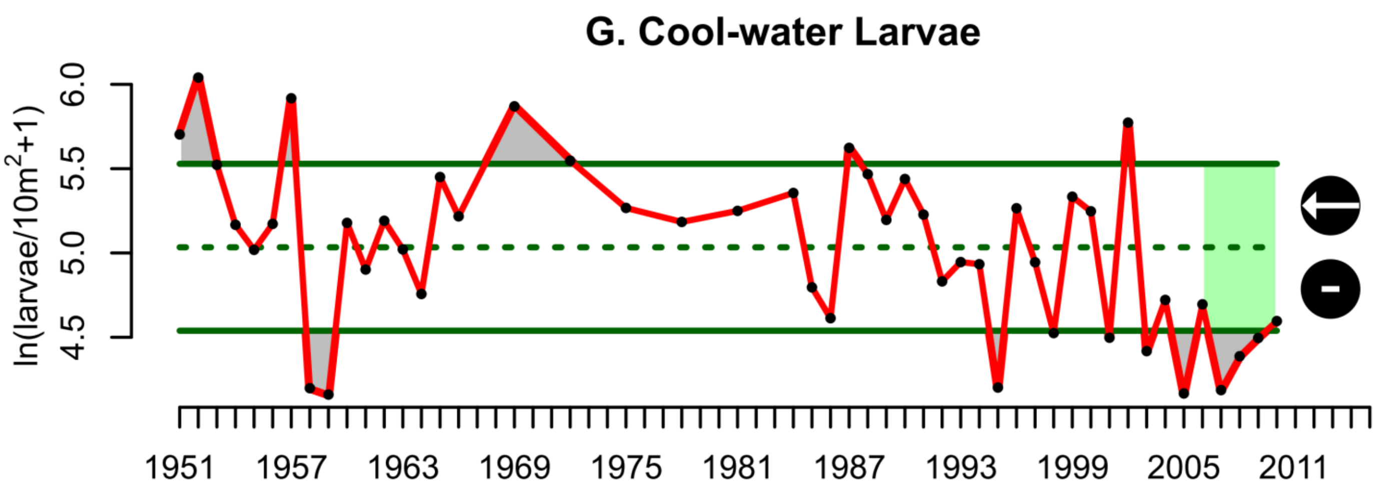
2 sources of acidic waters in the California current system:

- Upwelled waters
- Equatorial waters

These waters have signatures in the ichthyoplankton assemblage structure.

Hypothesis is that changes in ichthyoplankton assemblages and water mass properties provides an index of acidic waters and change over time.





Modeling sardine recruitment (GAMs, GLMs) (temperature control rule)

Lindegren and Checkley 2012, CJFAS, Hurtado-Ferro and Punt 2013, unpublished.

- A proposal to re-instate the temperature control rule for sardine is being considered.
- The implications of using the offshore CalCOFI temperatures rather than SIO pier (or not using a temperature control rule) is a drastic reduction in permitted catches.

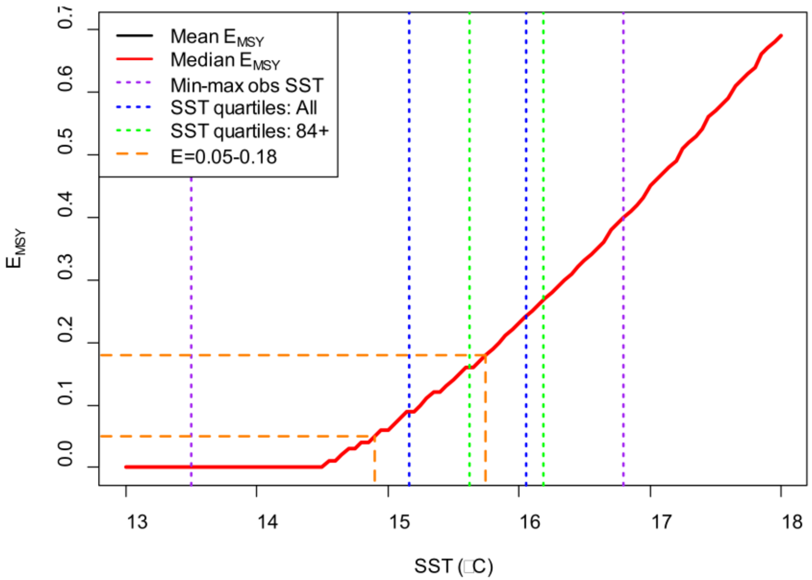


Figure 3. Relationship between CalCOFI SST and E_{MSY}, showing quartiles of observed SST in the SST_CC_ann time series.

Table 2. Impact of changing the environmental variable from SIO to CalCOFI, using both annual and 3-year averages.

Mgmt	Biomass	SIO				CalCOFI ann					CalCOFI 3-year average				
year	(July)	SST	Fraction	HG	OFL	ann SST	Fraction	HG	Difference	OFL	3-y SST	Fraction	HG	Difference	OFL
2000	1581346	18.08	0.15	186791	605339	15.19	0.09	113150	-73641	125008	16.18	0.15	186791	0	331561
2001	1182465	17.75	0.15	134737	433005	15.73	0.15	134737	0	185281	15.82	0.15	134737	0	202183
2002	1057599	17.24	0.15	118442	149081	15.50	0.14	110000	-8442	128179	15.47	0.14	106625	-11817	124247
2003	999871	17.31	0.15	110908	165969	14.91	0.05	38097	-72811	44821	15.38	0.12	88639	-22270	104283
2004	1090587	17.46	0.15	122747	246185	15.98	0.15	122747	0	214618	15.46	0.13	109008	-13738	126392
2005	1193515	17.60	0.15	136179	346672	15.78	0.15	136179	0	196454	15.56	0.15	135381	-797	154842
2006	1061391	18.03	0.15	118937	406300	15.36	0.12	93036	-25900	108349	15.71	0.15	118937	0	162261
2007	1319072	18.11	0.15	152564	504941	15.72	0.15	152564	0	203690	15.62	0.15	152564	0	184025
2008	832706	18.12	0.15	89093	318760	15.06	0.07	42989	-46104	52435	15.38	0.12	71394	-17699	87081
2009	662886	17.83	0.15	66932	253753	15.13	0.08	36621	-30311	47331	15.30	0.11	48181	-18750	62272
2010	702024	17.84	0.15	72039	268735	15.15	0.08	40617	-31422	51654	15.11	0.08	38243	-33796	48634
2011	537173	17.90	0.15	50526	205630	15.49	0.14	46600	-3926	64654	15.26	0.10	33950	-16576	47103
2012	988385	17.64	0.15	109409	307746	14.82	0.05	36470	-72939	42995	15.15	0.09	62453	-46956	73627
2013	659539	17.35	0.15	66495	118854	-	-	-	-	-	-	-	-	-	-

Summary

1. **Strengths**

- High quality, long term data sets available for analyses.
- Highly experienced staff and excellent lab facilities.
- Strong publication record.
- Established collaborations with researchers at Scripps Institution of Oceanography.

2. **Main challenges**

- Staffing levels are too low in the face of increasing demands for oceanographic analyses, sample processing, and increased survey days.
  - Fisheries oceanography runs on 2 FTEs (one who is not an oceanographer) plus an externally funded postdoc. 1 data processing staff member lost to retirement.
  - Ichthyoplankton lab is reduced to one contract sorter (previously there were 5-6).
  - Ship operations needs to replace two sea-going FTEs.

Summary continued

3. **Strategies for improvements (i.e., to address the challenges)**

• Hire appropriate staff (2 FTEs under Ship Operations, contract plankton sorters under Ichthyoplankton, a contract programmer under Fisheries Oceanography, more oceanographers).

• Leverage collaborations, e.g. with PMEL climatologists such as Nick Bond & Jim Overland.

• Reduce the sea-going demands on staff and resources, or increase the level of resourcing.

• Support the integration of observing systems (gliders, moorings, autonomous profilers, and remote sensing analyses) to expand spatial and temporal sampling resolution.